

EFFECT OF NANO LUBRICANT ON THE PERFORMANCE OF COMPRESSOR IN THE REFRIGERATION SYSTEM

Submitted in partial fulfillment of the requirement for the award of
Bachelor of Engineering degree in Mechanical Engineering

Project carried out by

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DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY (DEEMED TO BE
UNIVERSITY)**

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Vanapalli Sai Krishna(39150127)** and **G S Sarath Kumar (39150117)** who carried out the Project entitled - **“EFFECT OF NANO LUBRICANT ON THE PERFORMANCE OF COMPRESSOR IN THE REFRIGERATION SYSTEM”** under our super vision from December 2022 to April 2023.

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We **VANAPALLI SAI KRISHNA (39150127)** and **SARATH KUMAR G S (39150117)** hereby declare that the Project Report entitled “**EFFECT OF NANO LUBRICANT ON THE PERFORMANCE OF COMPRESSOR IN THE REFRIGERATION SYSTEM**” done by us under the guidance of **Dr. S. P. Venkatesan, Ph.D.**, at Sathyabama University is submitted in partial fulfillment of the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 26.04.2023

PLACE: Chennai

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ABSTRACT

Many developing countries, such as India, are currently experiencing energy shortages. Refrigeration has become a major energy consumer in many industrial and household applications. As a result, it is necessary to improve the refrigeration system's energy efficiency. The refrigeration system's performance can be improved either by increasing the rate of heat absorption in the evaporator or reducing the compressor power. The use of efficient lubricant oil can be helpful in the removal of heat generated during the compression process, which may result in less power consumption. Nanotechnology advancements have enabled for development of a new class of lubricant known as nano-lubricant, in which nano-particles are mixed up into lubricant base oil for the improvement of thermal properties. To create a stable nano-lubricant, a double-step technique is taken with ultrasonic agitation force. The current study experimentally investigates the performance of an R134a refrigerant vapor compressing refrigeration system with the help of nano lubricant in different volume concentrations of Al₂O₃ to mineral oil (MO). The results show that the Nano lubricant has significant improvements in COP volume fraction when compared to the base fluid. The need for nano lubricants is to reduce the compressor power consumption.

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CHAPTER-1 : INTRODUCTION

Nanotechnology permits the creation of nano-particles, which are metal or metal oxide particles with diameters ranging from 1 to 100 nanometers. Nanofluid is in high demand in many heat transfer applications such as renewable energy systems, refrigeration and air conditioning, automobile, electronic cooling, and so on due to its improved heat transfer properties such as thermal conductivity and specific heat when compared to conventional heat transfer fluids such as oil, water, and air. When comparing it to traditional heat transfer fluids, it has superior heat transfer characteristics such as thermal conductivity and specific heat.

The thermal conductivity of the fluid can be increased by incorporating nanoparticles into the base fluid. The volume % as well as the types of nanoparticles used to determine heat transfer performance. Metals, oxides, and carbides are the most common materials used to make nanoparticles. Nano-fluid has improved thermal characteristics, reduced sedimentation, and less clogging flow lines due to the nanoparticle's compact volume and huge surface area. As a result, nanofluid is an enhanced heat transmission fluid. Nanofluid can be created in a single process or two steps. The two-step process is typically employed to create huge volumes of nanofluids. This procedure begins with the preparation of a dry nanopowder of the desired size. The nanopowder is then mixed with the required base liquid and a surfactant to create a stable nanoparticle/base fluid mixture.

Mechanical stirring, ultrasonic or magnetic agitation can be employed to achieve uniform dispersion of nanoparticles in liquids).

Oil has been used for cooling and lubricating the working elements of the compressor in vapor compression refrigeration (VCR) systems, which can extend the compressor's life and performance. According to a report by an HVAC system developer, during operation, approximately 50% of the lubricant volume remains in the compressor while the remaining is combined with refrigerant in other elements of the system such as the condenser, pipes, evaporator, and so on. A lubricant that uses nanoparticles as additives to enhance its thermal properties is referred to as a "Nano-lubricant."

Given nanofluids' improved heat transfer capability, researchers have recently concentrated their efforts on investigating the efficacy of nano lubricants in refrigeration and air conditioning systems. Sanukrishna et al. (2018) investigated the effect of metal oxide nanoparticles on the thermal properties and tribological behaviour of compressor polyalkylene oil analytically. According to Lin and Kedzierski (2018), the specific heat of an Al₂O₃/POE nano lubricant increases linearly with increasing temperature and drops linearly with increasing nanoparticle volume concentration.

The effect of h-BN/Poly-OI ester oil (POE) even as a lubricant on a VCR's operation when R134a is used as the refrigerant. In POE oil, they used a 0.1% to 0.4% volume fraction of h-BN nanoparticlecles. They found that using 0.3% volume concentration nanofluid as opposed to base oil resulted in a 60% increase in the coefficient of performance (COP) as well as an increase in anti-friction behavior. Pico et al. (2019) discovered a maximum 8% increase in COP when using POE/Diamond nano lubricant at 0.2% to 0.5% mass concentration in the VCR system with R410A refrigerant. They also noticed that there is 4°C decrease in compressor discharge temperature, which results in a decrease in compression power. The usefulness of Copper oxide and Poly-alkylene Glycol (PAG) oil as a lubricant in the VCR system at volume concentrations ranging from 0.01% to 0.025% CuO has also been investigated by Prasad and Kumar. They reported a 25% increase in COP when using nano lubricant versus PAG oil.

The current study is aimed at looking at the performance of an Al₂O₃/MO nano lubricant in a Vapour compressor refrigeration system using R134a as a refrigerant.

NANO - TECHNOLOGY:-

- Nanotechnology is a field of science and technology that deals with the manipulation and engineering of matter on an extremely small scale, typically on the order of nanometers (one billionth of a meter). At this scale, materials can exhibit unique properties that are not present at larger scales, and can be utilized to create novel materials, devices, and systems with unprecedented properties and functions. Brown haze and corrosive rain are precursors of NO_x. NO_x is made up of NO and NO₂, and NO₂ nullifies respiratory contaminant protection.

- Nanotechnology has many applications in various fields, such as medicine, electronics, energy, and materials science. It can be used to create new and improved materials, such as lightweight and strong materials, self-cleaning surfaces, and flexible electronics. It also has the potential to revolutionize medicine, by enabling targeted drug delivery, early disease detection, and advanced imaging technologies.

- The development of nanotechnology involves the use of various techniques and tools, such as scanning probe microscopy, electron microscopy, and nanolithography. These techniques allow scientists and engineers to manipulate and assemble atoms and molecules with precision, and to study the properties and behavior of materials at the nanoscale.

- Despite the many potential benefits of nanotechnology, there are also concerns about its safety and ethical implications, particularly with regard to the potential risks associated with exposure to nanoparticles and the environmental impact of nanomaterials. As such, there is a need for continued research and regulation to ensure that the benefits of nanotechnology are realized safely and responsibly.

: R134a Compressor :-

- R134a is a type of refrigerant used in air conditioning and refrigeration systems. The compressor in an R134a system is responsible for compressing the refrigerant gas and circulating it through the system to transfer heat from the indoor environment to the outdoors..
- The compressor in an R134a system works by using an electric motor to drive a piston that compresses the refrigerant gas. As the gas is compressed, its temperature and pressure increase, causing it to release heat to the surrounding environment. The compressed gas then flows through a series of coils or tubes where it is cooled by air or water, allowing it to condense back into a liquid.
- Once the refrigerant has condensed, it passes through an expansion valve or orifice, which reduces its pressure and temperature. This cold liquid then flows through a series of coils or tubes inside the indoor environment, where it absorbs heat and cools the air. The refrigerant then returns to the compressor to repeat the cycle.

: ULTRASONICATION:-

- Ultrasonication is the process of using high-frequency sound waves to agitate a liquid or solid material. The sound waves, which typically have frequencies above 20 kHz, are produced by a device called an ultrasonic transducer.
- When the sound waves enter the material, they create small bubbles or cavities in the liquid or solid. These bubbles then rapidly expand and collapse, generating a lot of energy in the process. This energy can be used for a variety of purposes, such as cleaning, mixing, emulsifying, homogenizing, and extracting.
- Ultrasonication has a wide range of applications across many industries, including food, pharmaceuticals, cosmetics, and nanotechnology. Some of the benefits of ultrasonication include increased efficiency, reduced processing time, and improved product quality. However, it is important to use the appropriate equipment and parameters for each application to ensure the desired results are achieved without damaging the material being processed.

: Al₂O₃ NANO PARTICLE :-

- Al₂O₃ nano particles refer to particles of aluminum oxide (Al₂O₃) that have a size of less than 100 nanometers. These particles have unique physical and chemical properties that make them useful in various applications such as catalysis, ceramics, coatings, and electronics.
- The small size of Al₂O₃ nano particles gives them a large surface area to volume ratio, which enhances their reactivity and catalytic activity. They also exhibit high mechanical strength, thermal stability, and chemical inertness, making them suitable for use in high-temperature and harsh chemical environments.
- Al₂O₃ nano particles can be synthesized using various methods such as sol-gel, hydrothermal, and plasma methods. The properties of the particles

depend on the synthesis method, as well as the size and shape of the particles.

- Overall, Al₂O₃ nano particles have a wide range of potential applications, and ongoing research is exploring new ways to use these versatile materials.

: NANO - LUBRICANTS:-

- Nano lubricants are a type of lubricant that contains nanoparticles, which can provide improved lubrication and other beneficial properties. However, the use of nano lubricants in refrigeration compressors is not very common, as traditional lubricants such as mineral oil and synthetic oil are already effective in providing lubrication to the compressor.
- Additionally, the use of nano lubricants in refrigeration compressors may not be practical due to the risk of clogging the narrow passages in the compressor. This could potentially lead to decreased efficiency and increased wear and tear on the compressor
- Therefore, it is important to consult with a qualified refrigeration technician or manufacturer before considering the use of nano lubricants in a refrigeration compressor. They can provide guidance on the suitability of the lubricant for your specific compressor and application.

CHAPTER-2: LITERATURE SURVEY

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CHAPTER-3: AIM AND SCOPE OF WORK

: AIM OF THE WORK:-

need to conduct experiments and tests to evaluate the lubrication properties and compatibility of different types of lubricants with the refrigerant and compressor system.

To find a suitable nano lubricant for use in a refrigerant compressor, you may need to consider the following factors:

- **Compatibility with the refrigerant:** The nano lubricant should be compatible with the refrigerant used in the compressor. Some refrigerants can react with certain types of lubricants, leading to system failure or reduced efficiency.
- **Lubrication properties:** The nano lubricant should have good lubrication properties, such as low friction and high wear resistance, to improve the performance and lifespan of the compressor.
- **Particle size and distribution:** The size and distribution of the nanoparticles in the lubricant can affect its effectiveness. Ideally, the particles should be small and evenly distributed throughout the lubricant to provide maximum lubrication benefits.
- **Stability:** The nano lubricant should be stable under the conditions of the refrigerant compressor, including temperature and pressure fluctuations, to avoid degradation or breakdown over time.
- **Cost:** The cost of the nano lubricant should be reasonable and should provide a good return on investment in terms of improved system performance and efficiency.

:SCOPE OF THE WORK:-

Nano lubricants are being increasingly used in refrigeration compressors due to their ability to reduce friction, wear and tear, and improve energy efficiency. The following is a brief overview of some recent research on the use of nano lubricants in refrigeration compressors:

- A study published in the Journal of Mechanical Science and Technology in 2021 evaluated the performance of a refrigeration compressor using a lubricant containing nanoparticles of Aluminum oxide. The results showed that the use of the nano lubricant led to a reduction in friction and wear, and improved the overall energy efficiency of the compressor.
- Another study published in the Journal of Mechanical Engineering Science in 2020 investigated the effect of adding nano-diamond particles to the lubricant used in a refrigeration compressor. The researchers found that the use of nano-diamonds led to a reduction in friction and wear, and also improved the heat transfer properties of the lubricant.
- A study published in the Journal of Applied Thermal Engineering in 2019 evaluated the performance of a refrigeration system using a lubricant containing nanoparticles of aluminum oxide. The results showed that the use of the nano lubricant led to a reduction in energy consumption and improved the heat transfer properties of the refrigeration system.
- A study published in the International Journal of Refrigeration in 2018 investigated the use of nano-lubricants in a refrigeration compressor operating at low temperatures. The results showed that the use of the nano lubricant led to a reduction in friction and wear, and also improved the stability and flow properties of the lubricant at low temperatures.

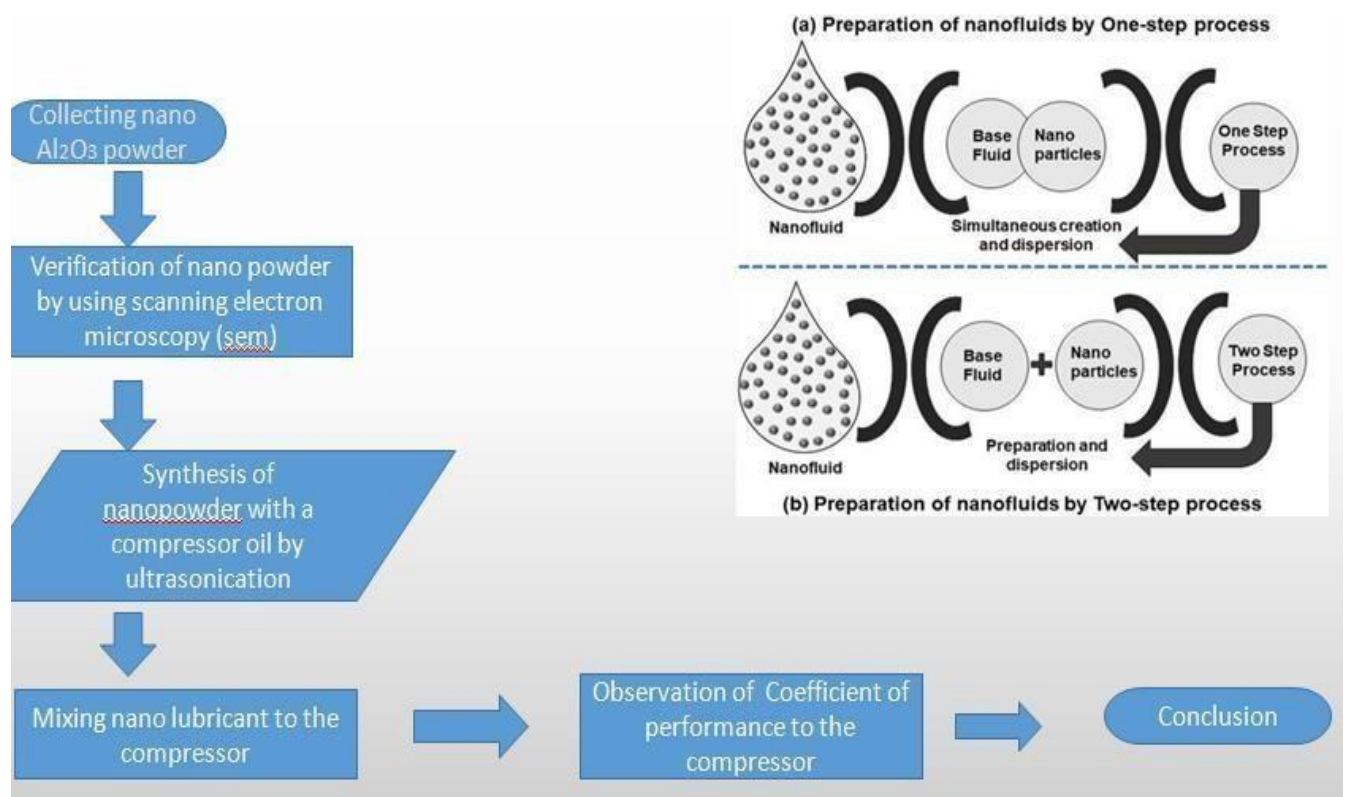
Overall, these studies suggest that the use of nano lubricants in refrigeration compressors can lead to significant improvements in performance, energy efficiency, and durability. However, more research is needed to fully understand the long-term effects of using these lubricants, as well as their potential impact on the environment.

CHAPTER- 4: MATERIALS AND METHODS

: MATERIALS:-

- Refrigeration Compressor – R134a
- Nano Particles – Al_2O_3
- POE Mineral oil.
- Pressure Gauge.
- Thermometer.
- Energy meter.

: METHODOLOGY:-



: METHODS:-

:Collecting of Al₂O₃ Nano Powder:-

Identify a reputable supplier: Look for a supplier of Al₂O₃ nano-powder online that has a good reputation and reviews. Check that they offer the type and quantity of Al₂O₃ nanopowder you need as shown in the figure-4.3.1.



FIGURE-4.1 :- AL₂O₃ Nano Powder

Check the specifications: Make sure the Al₂O₃ nanopowder offered by the supplier meets your requirements for particle size, purity, and other properties

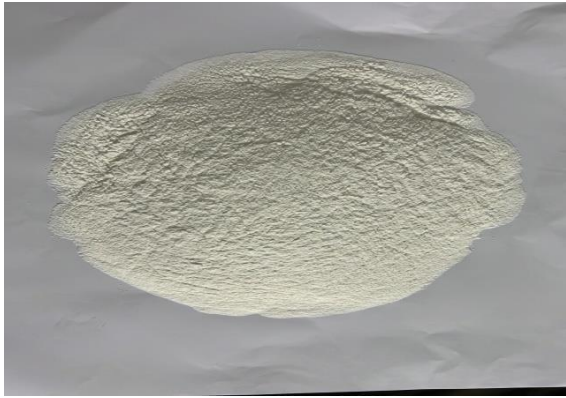


FIGURE- 4.2:- POWDER of Al₂O₃.

Table 1. Specifications of Al₂O₃ used in this study.

Property	Al ₂ O ₃ nanopowder
Purity	99.9%
Average particle size	20 nm
Molecular weight	101.96 g/mol
Density	3.9 g/cm ³
Thermal conductivity	35 W/m ² K
Specific heat	880 J/Kg•°K

TABLE – 4.1 Specifications of Al₂O₃

Place an order: Place an order with the supplier and make sure to provide accurate information about the quantity, specifications, and shipping details.

Payment and delivery: Make payment for the Al₂O₃ nanopowder through the supplier's online payment system, and confirm the expected delivery date. Ensure that the supplier provides adequate packaging to protect the nanopowder during shipping.

Quality control: Upon receiving the Al₂O₃ nanopowder, perform quality control tests to ensure that the nanopowder meets the required specifications. This may include testing for particle size, purity, and other properties.

It is important to note that the specific steps for collecting Al₂O₃ nanopowder online may vary depending on the supplier and the platform used for purchasing. Always ensure that you are dealing with a reputable supplier and that you understand the terms and conditions of the transaction before placing an order.

Al₂O₃ nano particles refer to particles of aluminum oxide (Al₂O₃) that have a size of less than 100 nanometers. These particles have unique physical and chemical properties that make them useful in various applications such as catalysis, ceramics, coatings, and electronics.

The small size of Al₂O₃ nano particles gives them a large surface area to volume ratio, which enhances their reactivity and catalytic activity. They also exhibit high mechanical strength, thermal stability, and chemical inertness, making them suitable for use in high-temperature and harsh chemical environments..

: SEM (Scanning Electron Microscopy) Analysis of Nano Powder:-

SEM (Scanning Electron Microscopy) analysis of nano powder is a useful technique to observe the morphology and structure of the particles. Here are the general steps for SEM analysis of nanopowder

Sample preparation: The first step is to prepare a sample of the nanopowder for SEM analysis. This may involve spreading the powder onto a flat surface, such as carbon tape or a microscope slide.

Mounting the sample: The prepared sample is mounted on a SEM sample holder using a conductive adhesive, such as carbon tape, to ensure that the sample is grounded and conductive.

Sputter coating: In order to improve the conductivity and resolution of the nano particles, a thin layer of conductive material such as gold, platinum, or carbon is deposited on the sample surface using a sputter coater.

SEM Imaging: The sample is then placed in the SEM chamber and subjected to high-energy electrons, which generate a signal that can be used to generate an image of the sample. The SEM is operated at a high vacuum to prevent the interaction of electrons with gas molecules and generate high-resolution images of the sample.

Image analysis: Once the SEM images of the nanopowder are obtained, they are analyzed using various software tools to extract information about the particle size, morphology, and distribution.

It is important to note that the specific steps for SEM analysis of nano powder may vary depending on the type of powder, the SEM instrument, and the research objectives. SEM analysis should always be conducted by experienced researchers to ensure an accurate interpretation of the results.

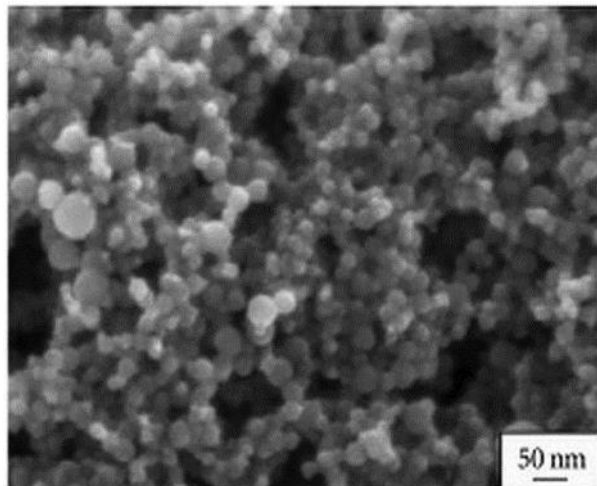


FIGURE-4.3: SEM of aluminum oxide Nano powder.

Al_2O_3 nano particles can be synthesized using various methods such as sol-gel, hydrothermal, and plasma methods. The properties of the particles depend on the synthesis method, as well as the size and shape of the particles

Overall, Al_2O_3 nanoparticles have a wide range of potential applications, and ongoing research is exploring new ways to use these versatile materials.

: Refrigeration Compressor oil:-

:- Different types of compressor oils :-

Different types of compressor oils are used in refrigeration systems for a variety of reasons, including:

- **Compatibility with refrigerants:** Different types of refrigerants used in refrigeration systems may require different types of compressor oils for optimal performance and compatibility.
- **Viscosity:** Compressor oils come in different viscosity grades that are suited to different operating temperatures and pressures of the refrigeration system. Some refrigeration systems operate at high temperatures and pressures, while others operate at lower temperatures and pressures. The viscosity of the oil used in the compressor should be selected based on the operating conditions of the system
- **Oil additives:** Some compressor oils contain additives that improve their performance in certain operating conditions. For example, some oils may contain anti-wear additives that help to protect the compressor from wear and tear, while others may contain anti-foaming agents that help to reduce foam and improve oil circulation.
- **Compatibility with compressor materials:** Some compressor oils may be better suited to certain types of compressor materials, such as aluminum or steel. Using the wrong type of compressor oil can lead to corrosion or other damage to the compressor.
- **In summary,** selecting the right type of compressor oil for a refrigeration system is important to ensure optimal performance, and compatibility with refrigerants, and to protect the compressor from wear and tear. The specific requirements for compressor oil will depend on the specific refrigeration system and its operating conditions.

Refrigerator compressors require lubrication in order to function properly and prevent damage to the compressor. The lubricant used in refrigeration compressors is usually a special type of oil called refrigeration compressor oil, which is specifically designed to handle the high pressures and temperatures that occur in refrigeration systems.

R134a is a type of refrigerant used in many air conditioning and refrigeration systems. Compressor oil is used in R134a systems to lubricate the compressor and other moving parts

The type of compressor oil used in R134a systems is usually a synthetic polyolester (POE) oil. This type of oil is highly resistant to chemical breakdown and can withstand the high temperatures and pressures that are present in a refrigeration system. POE oils are also compatible with R134a refrigerant, which is important for maintaining the efficiency and performance of the system

: - POLYOLESTERR OIL(POE):-

POE compressor oil has several uses in refrigeration and air conditioning systems that use HFC refrigerants. Some of its uses include:

- Lubrication: POE compressor oil is used to lubricate the moving parts of the compressor, reducing friction and wear.
- Heat transfer: POE compressor oil helps transfer heat away from the compressor to maintain efficient operation and prevent overheating
- Corrosion protection: POE compressor oil provides corrosion protection to the compressor and other system components, preventing rust and other types of corrosion.
- Environmental benefits: POE compressor oil is an environmentally friendly alternative to traditional mineral oil lubricants, as it does not contain harmful chemicals such as chlorine and is biodegradable.
- Compatibility with HFC refrigerants: POE compressor oil is specifically designed to be compatible with HFC refrigerants, which are commonly used in modern refrigeration and air conditioning systems.
- Overall, POE compressor oil plays an essential role in maintaining the efficient and reliable operation of refrigeration and air conditioning systems that use HFC refrigerants.

Using the correct type of compressor oil is important for maintaining the efficiency and longevity of the system. The oil helps to lubricate the compressor, which reduces friction and wear on the moving parts. It also helps to remove heat from

the compressor, which helps to keep it operating at a safe temperature. In addition, the oil helps to remove any contaminants or moisture that may be present in the system, which can improve its performance and reduce the risk of damage or failure.

It's important to note that not all refrigeration compressor oils are interchangeable, and using the wrong type of oil can lead to poor performance, premature compressor failure, and potentially hazardous conditions. Therefore, it is important to follow the manufacturer's recommendations when selecting and changing the compressor oil in your refrigerator.



FIGURE -4.4:- Compressor oil.

4.3.4.1: REFRIGIRATION COMPRESSOR:-

There are different types of refrigeration compressors, including reciprocating compressors, rotary compressors, screw compressors, and centrifugal compressors. Each type has its own advantages and disadvantages, and the selection of the compressor depends on factors such as the size of the system, the required cooling capacity, and the operating conditions.

In refrigeration, compressors are used to compress the refrigerant gas from low pressure to high pressure, which increases the temperature of the refrigerant. The high-pressure refrigerant then flows through the condenser, where it releases heat and changes its state from a gas to a liquid.

Different types of compressors are used in refrigeration systems because each type has unique advantages and disadvantages, and is suited to different

applications. Here are some of the most common types of compressors used in refrigeration:

- **Reciprocating Compressor:** This is the most common type of compressor used in refrigeration. It operates by compressing refrigerant gas with a piston that moves back and forth inside a cylinder. It is best suited for small to medium-sized refrigeration systems.
- **Rotary Compressor:** This type of compressor uses a rotating mechanism to compress the refrigerant gas. It is quieter and more efficient than reciprocating compressors and is well-suited for larger refrigeration systems.
- **Scroll Compressor:** This compressor uses two spiral scrolls to compress the refrigerant gas. It is more efficient and reliable than reciprocating compressors and is commonly used in air conditioning systems.
- **Screw Compressor:** This compressor uses two interlocking screws to compress the refrigerant gas. It is efficient and reliable, making it ideal for large commercial refrigeration systems.
- **Centrifugal Compressor:** This type of compressor uses a rotating impeller to compress the refrigerant gas. It is best suited for large industrial refrigeration systems.

Each type of compressor has its own set of advantages and disadvantages, and the choice of compressor will depend on factors such as the size of the refrigeration system, the required efficiency, and the specific application. Energy conservation and environmental preservation will result from a compressor's efficiency being improved. Two crucial factors in the performance of compressors' dependability and efficiency are the lubricant's characteristics and the working environment.

The performance of numerous components in the vapor-compression refrigeration systems can be enhanced with the most recent advancements in nanotechnology. By using nanoparticles as lubricant additives, it is feasible to achieve more ecologically friendly conditions and improve heat transfer performance

4.3.5: REFRIGERATION SYSTEM:-

A refrigeration system is a mechanical system designed to remove heat from a specific area or substance and transfer it to another area or substance. The primary purpose of a refrigeration system is to maintain a low temperature within an enclosed space, such as a building, vehicle, or food storage area. Refrigeration systems are commonly used in commercial, industrial, and residential settings to preserve food and other perishable items, cool and condition air, and maintain comfortable temperatures in living and working spaces.

The basic components of a refrigeration system include a compressor, a condenser, an expansion valve, and an evaporator. The compressor compresses the refrigerant gas, raising its temperature and pressure. The high-pressure gas then flows through the condenser, where it releases heat and condenses into a liquid. The liquid refrigerant then passes through the expansion valve, which reduces its pressure and temperature. The low-pressure liquid then enters the evaporator, where it absorbs heat and vaporizes into a gas. The cycle then repeats as the gas is drawn back into the compressor.

There are several types of refrigeration systems, including air-cooled, water-cooled, and absorption systems. Air-cooled systems use air to remove heat from the condenser, while water-cooled systems use water. Absorption systems use heat energy to drive the refrigeration process, making them more energy-efficient than traditional systems. Refrigeration systems are crucial for many industries and applications, from food storage and transportation to pharmaceuticals, manufacturing, and more.

The compressor is responsible for compressing the refrigerant, which increases its temperature and pressure. The hot, high-pressure refrigerant then flows to the condenser, where it releases heat to the surrounding environment and condenses back into a liquid.

Next, the liquid refrigerant flows through an expansion valve, which reduces its pressure and temperature. The low-pressure, low-temperature refrigerant then enters the evaporator, where it absorbs heat from the surrounding environment and evaporates back into a gas.

Finally, the low-pressure gas is drawn back into the compressor to begin the cycle again.

Refrigeration systems are used in a wide range of applications, from small refrigerators and air conditioning units to large industrial cooling systems. They are essential for preserving food and other perishable items and for providing comfort in hot climates

: PREPARATION OF NANO LUBRICANT:-

Nanolubricants are lubricants that contain nano-sized particles in their composition, which can enhance their lubrication properties. Here are the general steps to prepare a nanolubricant:

- Selection of base lubricant: Choose a suitable base lubricant that is compatible with the nanoparticles to be added. Common base lubricants include mineral oils, synthetic oils, and vegetable oils.
- Selection of nanoparticles: Choose the appropriate nanoparticles that can improve the lubrication properties of the base lubricant. Common nanoparticles used in nanolubricants include carbon nanotubes, graphene oxide, and metal oxides like titanium dioxide or zinc oxide.
- Preparation of nanoparticles: The nanoparticles must be prepared by a suitable method that can ensure their uniform size and dispersion in the base lubricant. Techniques such as sol-gel, chemical precipitation, and ball milling can be used to prepare nanoparticles.
- Dispersion of nanoparticles in base lubricant: The nanoparticles are added to the base lubricant and then dispersed by various methods like ultrasonication, magnetic stirring, or homogenization. This step is crucial to ensure that the nanoparticles are well dispersed throughout the base lubricant.

- Characterization of nanolubricant: The final step involves characterizing the nanolubricant to ensure its properties meet the desired specifications. This may include measuring viscosity, thermal conductivity, wear resistance, and other relevant properties.
- It is important to note that the preparation of nanolubricants can be a complex process and requires specialized equipment and expertise. Therefore, it is advisable to seek the assistance of a qualified researcher or research group with experience in this area.

: ULTRASONICATION:-

Ultrasonication is the process of using high-frequency sound waves to agitate a liquid or solid material. The sound waves, which typically have frequencies above 20 kHz, are produced by a device called an ultrasonic transducer.

When the sound waves enter the material, they create small bubbles or cavities in the liquid or solid. These bubbles then rapidly expand and collapse, generating a lot of energy in the process. This energy can be used for a variety of purposes, such as cleaning, mixing, emulsifying, homogenizing, and extracting.

Ultrasonication has a wide range of applications across many industries, including food, pharmaceuticals, cosmetics, and nanotechnology. Some of the benefits of ultrasonication include increased efficiency, reduced processing time, and improved product quality. However, it is important to use the appropriate equipment and parameters for each application to ensure the desired results are achieved without damaging the material being processed.

:SYNTHESIS OF NANO LUBRICANT USING ULTRA SONICATION:-

Synthesizing nano lubricants using ultrasonication is a widely studied area in materials science and engineering. The following is a general overview of the process:

- Preparation of base oil: A base oil, typically a mineral oil or synthetic oil, is chosen as a carrier fluid for the nanoparticles. The base oil is pre-treated to remove impurities and water.
- Selection of nanoparticles: Various nanoparticles can be used as lubricant additives, including graphene, carbon nanotubes, and metal oxides. The

selection depends on the intended application and the desired performance of the lubricant.

- Dispersion of nanoparticles: The nanoparticles are added to the base oil in a controlled manner, typically through sonication or other mechanical agitation methods. Sonication is preferred as it is a fast, efficient and scalable method.
- Optimization of sonication parameters: The parameters of ultrasonic treatment such as frequency, power, and sonication time are optimized to achieve maximum dispersion and uniform distribution of nanoparticles.
- Characterization of nano lubricant: The synthesized nano lubricant is characterized using various techniques such as particle size analysis, zeta potential, viscosity, and tribological properties.
- Performance evaluation: The synthesized nano lubricant is then evaluated for its performance by testing it in an appropriate test rig or tribometer. Performance parameters include wear resistance, friction reduction, and thermal stability.

Overall, ultrasonication is a powerful method for synthesizing nano lubricants with enhanced properties compared to conventional lubricants. The process is scalable and can be tailored for specific applications.

:DIGITAL THERMOMETER:-

Digital thermometers can be used in refrigeration to accurately measure the temperature inside the refrigerator. This is important to ensure that the refrigerator is maintaining a safe and consistent temperature to prevent the growth of bacteria and spoilage of food.

To use a digital thermometer in refrigeration, follow these step:

- Turn on the digital thermometer and make sure it is set to measure in Fahrenheit or Celsius, depending on your preference.
- Open the refrigerator and place the thermometer in the center of the middle shelf. Make sure it is not touching any food or containers.
- Close the refrigerator and wait for a few minutes to allow the thermometer to stabilize and get an accurate reading.
- Read the temperature on the digital display. The ideal temperature for a refrigerator is between 35 and 38 degrees Fahrenheit (or 1.7 and 3.3 degrees Celsius).
- If the temperature is not within the safe range, adjust the refrigerator's temperature setting and wait a few hours for the temperature to stabilize before checking it again with the thermometer.
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FIGURE-4.7:- Thermometers .

:DIGITAL CLAMP METER :-

A digital clamp meter is a type of electrical measurement tool that is used to measure electric current in a circuit. It works by clamping around the wire or cable that carries the current, which allows the meter to measure the magnetic field that is created by the flow of electricity

Digital clamp meters are typically more accurate than analog clamp meters and offer a variety of features such as data logging, backlit displays, and auto-ranging capabilities. They can measure both AC and DC currents, as well as other electrical parameters such as voltage, resistance, and frequency.

Digital clamp meters are commonly used by electricians, technicians, and engineers to diagnose electrical problems, verify current flow in circuits, and perform maintenance on electrical systems. They are also useful for testing the performance of motors, generators, and other electrical equipment.



FIGURE-4.8:- DIGITAL POWER METER.

: PRESSURE GAUGE :

To calculate the pressure gauge in a compressor, you will need to follow these steps:

- Determine the type of compressor: Is it a positive displacement compressor (such as a reciprocating compressor or rotary screw compressor) or a dynamic compressor (such as a centrifugal compressor or axial compressor)? The shape of the combustion chamber has not changed.
- Find the rated pressure of the compressor: Check the compressor manual or nameplate for the rated pressure of the compressor. This is the maximum pressure that the compressor is designed to operate at
- Determine the pressure range of the gauge: Select a pressure gauge that can measure the pressure range of the compressor. The pressure gauge should have a range that is higher than the maximum pressure of the compressor. Performance graphs, P-PV plots, and tabulated results
- Install the pressure gauge: Install the pressure gauge in a location where it can be easily read and where it is protected from damage. Connect the gauge to the compressor using a suitable pipe or hose.
- Check the accuracy of the pressure gauge: To ensure that the pressure gauge is accurate, compare it with a calibrated gauge or a pressure reference standard.

Record the pressure reading: Once the pressure gauge is installed and calibrated, record the pressure reading regularly to monitor the performance of the compressor. If the pressure reading is outside the normal range, investigate the cause and take corrective action if necessary.

: MINERAL OIL TESTING:-

The potential of Al₂O₃/MO nano lubricant in 0.5 tons capacity R134a-MO-based vapor compression refrigeration

The test setup consists of a Kirloskar make hermetically sealed compressor, finned tube air-cooled condenser, expansion devices, evaporator tank inbuilt with cooling coils to cool the water. The calibrated J-type thermocouples were used to record the temperature of the refrigerant at the inlet and outlet of the condenser, evaporator, and water tank. Two pressure gauges were used to measure condenser and evaporator pressure. The energy meter having a constant of 3200 Rev/Kwh was used to find the power consumption of the R134a-MO-based vapor compression refrigeration system. The rate of power consumption by the compressor was calculated by recording the time required by the energy meter for 10 revolutions. The water was filled in the evaporator tank

4.3.9 : Working of compressor:

A compressor is a vital component of a refrigeration system that is responsible for compressing the refrigerant gas and pumping it through the refrigeration cycle. The basic working principle of a compressor is the compression of the refrigerant gas from a low-pressure vapor state to a high-pressure vapor state.

When the refrigerant gas is in the evaporator, it absorbs heat from the surrounding environment, causing it to turn into a low-pressure vapor. This low-pressure vapor is then drawn into the compressor, where it is compressed by the action of pistons or a rotating mechanism.

As the refrigerant gas is compressed, its temperature and pressure rise significantly. This high-pressure vapor is then forced into the condenser, where it releases heat to the surrounding environment, causing it to condense into a high-pressure liquid.

The high-pressure liquid then passes through the expansion valve, where it is allowed to expand and turn back into a low-pressure vapor. This low-pressure vapor then passes back into the evaporator, where the process starts again.

In summary, the compressor is responsible for compressing the refrigerant gas, raising its pressure and temperature, and driving it through the refrigeration cycle.

Compressor oil plays a critical role in the operation of refrigeration compressors. It lubricates the moving parts of the compressor, reduces friction, and helps dissipate heat. Compressor oils are formulated with specific additives to provide better lubrication, protect against corrosion, and improve performance.

Replacing compressor oil with Al₂O₃ nanolubricant in a refrigeration compressor can offer several benefits. Al₂O₃ nanolubricants have been shown to improve the lubrication performance of compressor oils, reduce friction, and increase the efficiency of the compressor. They can also improve the heat transfer properties of the compressor, leading to better cooling performance.

When considering the replacement of compressor oil with Al₂O₃ nanolubricant, it is essential to understand the compatibility of the nanolubricant with the materials used in the compressor. It is also important to ensure that the nanolubricant is the appropriate type and viscosity for the compressor's specific operating conditions.

The replacement process involves draining the old compressor oil, cleaning the compressor's interior, and adding the appropriate amount of Al₂O₃ nanolubricant. It is important to follow the manufacturer's instructions and use the correct tools and equipment to ensure a proper replacement.

If you want to test a refrigerant compressor by adding new compressor oil to it, here are the general steps you can follow:

- Turn off the power to the compressor and disconnect the electrical connections.

- Remove the old compressor oil from the system, including any residual oil in the compressor.
- Install the new compressor oil into the compressor, following the manufacturer's instructions for the specific oil being used.
- Reconnect the electrical connections to the compressor.
- Turn on the power to the compressor and allow it to run for a short period of time, typically 30 minutes to an hour.
- Monitor the compressor's operation, including the temperature and pressure readings, to ensure that it is running smoothly and not experiencing any issues.

If the compressor runs without any issues, you can continue to use the system with the new compressor oil. If there are any issues or concerns, it may be necessary to further troubleshoot or seek professional assistance.

It's important to note that the process of adding new compressor oil to a refrigerant compressor should only be done by trained professionals with the appropriate knowledge and equipment. This is because refrigerant systems can be dangerous if not handled properly, and any mistakes can result in serious injury or damage.

In refrigeration, "COP" stands for "Coefficient of Performance," which is a measure of the efficiency of a refrigeration system. The COP is defined as the ratio of the cooling output to the energy input. Here's how you can find the COP in refrigeration:

Determine the amount of heat removed (cooling output) by the refrigeration system. This can be measured in BTUs (British Thermal Units) or kilowatts (kW).

Determine the amount of energy consumed (energy input) by the refrigeration system. This can be measured in kilowatt-hours (kWh) or watts (W).

Calculate the COP by dividing the cooling output by the energy input:

$$\diamond \text{ COP} = \text{Cooling Output} / \text{Energy Input}$$

The COP can be determined by measuring the cooling output and energy input, and then dividing the former by the latter

CHAPTER-5

RESULT AND DISCUSSION:

Thus the performance of R134a/VCR system was first proceeded with pure Mineral Oil lubricant. That results were considered as reference to compare the performance of VCR system with nanolubricant. The experimentation was carried out with the same conditions for nano lubricant with different volume fractions. By adding the nanoparticle in the mineral oil, the thermal properties of lubricant will be improved. Therefore, less power consumption to run the compressor with a increase of volume fraction of Al_2O_3 nanoparticles is noted. It has been shown that there is reduction in compressor power using 0.15% volume fraction of nano lubricant instead of mineral oil. The coefficient of performance is increased with increasing volume fraction of Al_2O_3 nanoparticles due to enhancement in thermal conductivity of the nanolubricant. The highest COP was observed at 0.15% volume concentration of Al_2O_3 nanoparticles. It is observed that there is approximately 75% increment in Coefficient Of Performance instead while using base lubricant MO. As in our system we use compressor which is hermetically sealed, in which partial amount of nano lubricant migrate with lubricant because of this refrigerating effect (RE) was also improved. So increase of cooling effect and less of work of compressor makes increase in COP of re Fridgeration system. It is observed that above 0.15% volume concentration of Al_2O_3 in Mineral Oil, the COP is decreases as the compressor work increases.

CHAPTER-6

CONCLUSION :

Therefore the Experimental test concludes that 0.15% amount of the Al_2O_3 nanoparticles will increase the heat absorbing capacity of evaporator and which

may decrease the work input for compressor which shows 75% increment in COP of Refrigeration system. Finally it concludes that 0.15% is the optimum volume concentration of Al₂O₃/MO nanolubricant for Vapor Compressor Refrigeration system.

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